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An Economic Analysis of Vegetation Management

National Forests in Mississippi, Ouachita National Forest and Chattahoochee National Forest

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AN ECONOMIC ANALYSIS OF VEGETATION MANAGEMENT ON THE NATIONAL FORESTS IN MISSISSIPPI, OUACHITA NATIONAL FOREST AND THE CHATTAHOOCHEE NATIONAL FOREST

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ABSTRACT

Many reasons exist for the use of one site-preparation method over another: Percentage of hardwood competition, cost, expected efficiency of method, and topography are just a few. Over a long rotation, the additional cost for a more intensive site-preparation technique to control hardwoods may not be economically justifiable. Therefore, two or more acceptable site-specific alternatives should be evaluated to see if the additional volume returns merit the increased costs.

Several national forests were surveyed for their methods of vegetation management. Personnel on each forest were asked to estimate a minimum and maximum percentage of hardwood competition at crown closure under a given control method. Also included were cost of implementation and a worst and best case estimate of control effectiveness. Most methods on these forests surpassed the 4-percent real hurdle rate required by the Forest Service. Results showed that the difference in return between the worst and best case scenarios was not great. Therefore, even if the most pessimistic occurrence of the outcome were true, the investment in control would usually merit undertaking.

Generally, the analysis indicated that an intensive site-preparation method was justified if the control was expected to reduce at least 50 percent of the expected hardwood competition at crown closure. Many variables are involved in the analysis and possibly many acres may be involved in a regeneration effort. It is therefore recommended that a site-specific analysis be undertaken when two or more methods are candidates for possible use.

Figure 1.—Hardwood competition with regenerated pine seedlings can be effectively controlled by several chemical or mechanical methods.

ASSUMPTIONS

1. For a given level of hardwood competition, there is some minimal level of site-preparation that may be achieved (planting with no control) of unwanted hardwoods in the course of preparing a site.

2. There is a control technique, mechanical or otherwise, used with varying degrees of hardwood competition. The selection of the method used is based upon topography, cost-efficiency of control, size, and number of hardwoods present in the harvested stand.

3. There is a 20-percent chance of drought in any given year on each of the three national forests observed. If control is initiated, 80 percent of the seedlings will survive. If no control is undertaken, no seedlings will survive.

4. The positive and negative benefits that hardwood management have upon wildlife is assumed to be a net zero effect.

5. Rates of return on control methods represent the dollar return on the increased volume achieved via an investment in a control method.

6. Soil movement and soil compaction have an effect on site productivity. Each hardwood management method employed has either negative, positive, or no effect on expected future yield.

7. The analysis assumes an unthinned, adequately stocked stand (700 trees per acre), and a 45-year rotation period.

8. Stumpage prices are current sawtimber and pulpwood prices for each area analyzed. Prices are assumed to increase 2 percent and 1 percent per year for sawtimber and pulpwood, respectively.

9. Treatment costs were supplied by the forests surveyed.

DEFINITIONS

Soil Productivity.—The capability of a soil to supply the physical, chemical, and biological long-term needs of trees under a climatic regime. Productivity is measured by tree growth rate.

Site Productivity.—An aggregation of several factors that determine the growth efficiency of timber. Site productivity equals site location (environmental factors influencing productivity) plus soil productivity, plus species selection (ability of a species to adapt and grow on a site), plus management (initial stocking, thinning, site preparation, competition control, prescribed fire), minus mortality (losses to fire, insects and diseases).

INTRODUCTION

Intensive site-preparation for regeneration of southern pine forests can be chemical, mechanical, or a mixture of both. The method used to control hardwoods may depend upon degree of hardwood competition, expected effectiveness of the method, site topography, expected site-productivity changes, and cost. If two or more alternatives are compatible for a particular site, it is wise to compare their estimated benefits and additional costs.

The following analysis is a model of the relationships in the control of hardwood vegetation. Discussed are soil disturbance, drought, and the competition of hardwoods for soil moisture, all of which affect site productivity and yields. An economic analysis also shows expected benefits of control methods over a 45-year rotation. The analysis is based on control techniques used on three national forests.

METHODS

Intensive site-preparation is intended to ensure a greater survivability of seedlings and to increase growth rate in the desired tree, especially in the initial years of growth. Benefits or costs may be attributed to particular site-preparation practices because of the degree of soil movement and compaction. Soil productivity varies with the positive or negative effects of the different practices.

To estimate the effectiveness (wood volume at rotation) and the efficiency (economic return on investment) of mechanical, nonmechanical, and mixed treatments, I analyzed data on the intensive site-preparation methods from three national forests in the Southern Region. From this information, the internal rate of return (IRR) and net present value (NPV) were calculated. This calculation signifies dollar return available for investing in an intensive site-preparation method.

The analysis is performed on an incremental (marginal) basis: The method of control is considered to be in addition to a minimal mechanical site-preparation technique. The benefit of control, therefore, is the difference in the estimated volume with control and that estimated without control. To show the effects upon future volume, an estimate of the control method's effect on site-productivity and the possible factor of drought were modeled into the analysis. Benefits are expected with control in times of drought because seedling survival is greater due to less competition from hardwoods. Additional benefits accrue to site-preparation methods that do not detract from soil productivity; that is, site productivity will be enhanced with control methods that minimize topsoil movements.

Soil movement and compaction effects were estimated from data found in Neary, Morris, and Swindel *(1)*. Site-preparation methods differ in their effects on the yield response at rotation. Estimated effects on yield were factored into the model created in this analysis to estimate incremental volume change from hardwood control. The effect on yield varied by management option from -8.0 percent to +2.5 percent.

To measure the effects upon yield of hardwood competition at regeneration, a hardwood competition model developed by Sprinz, Burkhart, and Greber *(2)* was used in this analysis. The constraint on this model is the 45-year rotation age. The growth increase resulting from less competition (due to hardwood control) has been documented to age 10 by the authors *(2)* and incorporated into their model. Benefits after this age are imputed by the model.

A limiting factor of this analysis is that national forests often have rotation ages more than 45 years. Because of the limitation of the model, analyses were only based on a 45-year rotation. Longer rotations would likely cause the performance measures (IRR and NPV) to decrease because of the decrease in fiber growth-rates in succeeding years is overcome by the discounting effect of longer rotations.

Foresters on the National Forests in Mississippi, the Ouachita National Forest in Arkansas, and the Chattahoochee National Forest in Georgia were asked to provide:

(1) site-preparation methods currently practiced on their forests for various levels of hardwood competition;

(2) contract cost per acre for implementation;

(3) for each instance of control used, the estimated percentage of stand basal area that would be expected to return as hardwoods at crown closure (a minimum and maximum estimate);

(4) the percentage of hardwood expected to be controlled by a method (a worst and best case estimate);

(5) site index;

(6) stumpage price;

(7) probability of drought.

An enumeration of this information except the probability of drought is found in tables 1 to 3. The probability of drought on all of these national forests was estimated at a 20-percent chance in any one year. The requested data allow a worst and best case estimate to be made of hardwood control.

Given the scenario of control, the hardwood competition model estimated an incremental volume. To be consistent with the Resource Planning Act estimates, current sawtimber and pulpwood stumpage prices were increased by a 2-percent and 1-percent real rate of annual growth, respectively, over the rotation. These estimated future stumpage prices were multiplied by the estimated incremental volume obtained by control.

The resulting future dollar benefit was compared with the control cost to calculate a real internal rate of return. Real

rates of return (where inflation has not been considered) were converted to nominal returns (those that would be found in the marketplace) by assuming an average annual inflation rate of 5 percent over the 45-year rotation. Net present value and present value calculations are also given as additional information for the decisionmaker.

RESULTS

Tables 4 to 6 show the results of data from several national forests entered into the Hardwood Competition model and subsequently modified for drought and soil-movement impacts. Estimated volumes that would occur with no control and with control are illustrated for each site-preparation method. Included are marginal volume changes due to hardwood-control and site-productivity changes.

Most effects on site-productivity do not make a profound difference in total expected incremental volume attributed to intensive site-preparation. It is important, however, to note that severe disturbances of topsoil such as windrowing can have a substantial retarding effect on final yield. Methods such as chop and herbicide, and chop and burn have a positive effect on soil productivity (and thus site productivity) and should be considered.

Total volume changes at rotation expected from a control effect were multiplied by anticipated future stumpage prices. These figures were compared with control costs (tables 7 to 9). Resulting internal rates of return provide the economic criteria to gauge relative efficiency of control methods. Alternatively, the net present value and the present value (at 4 percent) of the expected future stumpage revenues were calculated as well. If the real IRR is 4 percent or greater (the Forest Service's hurdle rate for forest investments), or if the net present value is greater than or equal to zero, then a method is economically worthwhile. Of course, if two or more methods are favorable, the one with the highest IRR or NPV would be the preferred choice. Present value (PV) calculation illustrates the possible maximum dollar expenditure for cost-effective control. It must be emphasized that these calculations are not indicative of the returns for a total forest investment. They show only the feasibility, if any, of a more intense site-preparation method to foster greater seedling survivability and increased growth.

Nominal rates of return ranged from 1.9 to 13.3 percent on the Chattahoochee, depending on the site-hardwood circumstance, the control method used, and the anticipated effectiveness of the method. The range of return on the Ouachita was 10.5 to 14.6 percent and on the National Forests in Mississippi 11.7 to 15.8 percent. Tables 7 to 9 show real and nominal internal rates of return for the best-and worst-case scenario for each control method.

Only on the Chattahoochee were there instances (six) where the real return for particular scenarios did not equal or exceed the Forest Service's required rate of return (4 percent). An analysis of the six instances that did not exceed the 4 percent hurdle rate suggests that when hardwood competition at crown closure is expected to be substantial (greater than 50 percent) and hardwood controlled is expected to be relatively slight (less than 40 percent), the control method will not be economically feasible. See table 8. In other cases where the expected percentage of hardwood control is high (tables 7 and 9), real returns in excess of 4 percent will be achieved. Acceptable alternatives for control that equal or exceed 4 percent should be compared against each other. Then, the highest NPV or IRR should be selected as the preferred choice for control.

Figure 2.—One chemical method of control is with direct application via a hand-held spot-gun application to the competing hardwood vegetation.

DISCUSSION

This paper shows the relative value of intensive site-preparation over minimal site-preparation for achieving greater survival and increased growth of young seedlings over a 45-year rotation. To consider drought in the analysis, the benefits of control were estimated by calculating an expected value of the probabilities of having drought (and its effect on value with and without control) or no drought.

Also, the benefits and costs of topsoil movement and compaction are modeled. The analysis is site specific: Staff of three forest supervisors were asked to provide data on control methods used, costs of implementation, percent of hardwood competition at crown closure relative to pine basal area, and the expected degree of hardwood control. The two decision criteria in the analysis (IRR and NPV) are related to the additional investment in site-preparation costs which

increase the likelihood of seedling survivability, growth, and increased or decreased site productivity.

Worst and best case scenarios are developed for each control method to estimate a range of values for the decision criteria. For example, on the Chattahoochee National Forest, cut surface treatments were calculated to return between 1.1 (least) and 6.8 percent (most) real return. See table 8. Return on more favorable scenarios than the worst case and less favorable than the best case would, of course, be somewhere between the two extremes. A nominal rate of return is also given in tables 7 to 9 to illustrate the more familiar "market" interest rate, which includes inflation (here assumed at a 5-percent annual rate). For decision purposes in this analysis, the real IRR and the real NPV should be used.

The 4-percent rate of return threshold that Forest Service programs must equal or surpass is met on most treatments analyzed. The exceptions include the worst-case assumptions concerning percentage of hardwoods eliminated with control and percentage of hardwood competition expected at crown closure on all methods of control on the Chattahoochee National Forest. See table 8. The worst case scenarios on other forests, however, did exceed the 4 percent required rate of return.

Generally speaking, the greater percentage of basal area expected to be in hardwoods at crown closure and the greater percentage of hardwood expected to be controlled, the more incremental stumpage volume will result from control. The rate of return and net present value, however, are further dependent upon cost of treatment and expected value of stumpage at rotation. If prices for a control method are relatively high and timber markets are relatively weak, rates of return will not be as high as in those scenarios with less costly methods. The same is true with timber markets that can expect to be strong relative to other regional markets.

The relative difference in timber market prices can be explained because of demand differentials, proximity of stumpage to markets, competition, topography of site, and quality and volume of timber sales. In this analysis, stumpage prices on both the Ouachita and the National Forests in Mississippi have a higher product value than those on the Chattahoochee. For analytical purposes, such a relative difference puts the latter forest at a disadvantage as far as achieving a given rate of return. This partly explains the lower returns expected for this forest. To be sure, no one can predict the changing circumstances that may occur in 45 years; however, other things being equal and assuming relative differences in markets tend to be essentially the same in the future, the relative differential in returns can be assumed to continue.

The investment in silvicultural practices in areas of strong stumpage demand is of more value than in such areas where the markets are not as strong. Hence, the returns on the Chattahoochee are not as good as might be expected if relative market conditions were expected to be better.

The second element affecting possible returns of the Chattahoochee versus the Ouachita and the National Forests in Mississippi was the effectiveness of control. Many of the worst case examples contained a relatively low percentage of hardwood control expected with a given, intensive site-preparation method. Moreover, expected basal area at crown closure was relatively low, and the percentage of hardwood controlled was low. Each condition would tend to give low rates of return.

Figure 3.—Chemical control by hand injection to the hardwood tree will reduce competition for sunlight and moisture for regenerated pine seedlings.

SUMMARY AND CONCLUSION

Site preparation techniques for hardwood competition with young pine seedlings were compared on several national forests. A range of estimates of percentage of hardwood basal area expected at crown closure and percentage of hardwood control expected with a control effort were asked of personnel on each forest. Most scenarios proved to be economically efficient given the Forest Service's required return to forest investments (4 percent real return).

On the Chattahoochee, however, there were some instances when the expected percentage of hardwood controlled was low. Also, expected hardwood basal area at crown closure was high. In some cases, both the expected percentage of hardwood controlled and expected percentage of basal area in hardwoods at crown closure were low. Such characteristics resulted in low rates of return for the scenario modeled.

Comparing rate of return for different methods among different forests is not advisable because these analyses are site specific. The results depend upon the judgment of the

individuals supplying the information and the cost of control. Comparisons of control methods within a particular forest can be done, and a worst-best case situation will give a strong indication whether the choice is correct. If the return in using a given treatment is acceptable for the best- and worst-case examples, then the method under consideration has a high probability of success. On the other hand, if a worst-case example has an unfavorable result and the best case is favorable, then there is less likelihood that a given scenario will represent a correct choice. Because of the element of risk (physical as well as economic), there is always an element of doubt about forecasts. When the best and worst case examples give a favorable economic signal, there is a great deal of confidence in such an analysis.

The dollar value listed under the Present Value column of tables 7 to 9 gives the decisionmaker information on the maximum amount per acre that can be spent on control and still yield an acceptable return.

When there is a large expenditure for regeneration, site-preparation methods that are qualitatively acceptable should be analyzed for quantitative acceptability before action on regeneration is made.

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2. Sprinz, Peter T.; Burkhart, Harold E.; Greber, Brian J. A model for the economic assessment of reducing hardwood competition in loblolly pine plantations. Blacksburg, VA: Virginia Polytechnic Institute and State University, School of Forestry and Wildlife Resources; [Unpublished.] p. 41.

Table 1.--Characteristics of control methods and incremental value expected at rotation because of control on the National Forests in Mississippi

Method of Control	Cost/AC	Expected % of BA in Hardwood At Crown Closure	Expected % Hardwood Controlled	Stumpage Price At Harvest (S/P)[1]	Incremental Stumpage Value
Granular Herbicide followed by Prescribed burn	$ 90	60	70	$353/$12	$3,159
		**60	80		3,852
		*70	70		2,946
		70	80		3,764
Foliar spray, Inject stems, Prescribed burn	$140	70	70		$2,946
		**70	80		3,764
		*80	70		2,671
		80	80		3,605
Stump spray W/Herbicide	$40	60	60		$2,560
		**60	70		3,294
		*70	60		2,251
		70	70		3,066
Prescribed burn followed by Injection	$80	80	70		$2,671
		**80	80		3,605
		*90	70		1,972
		90	80		3,394
Chemical Injection	$70	70	60		$2,251
		**70	70		3,066
		*80	60		1,904
		80	70		2,779
Soil Active Herbicide (Velpar) applied by spot gun, followed by Prescribed burn	$130	**90	80		$3,532
		*90	90		4,581

Continued

1 Price per MBF for sawtimber (S) and per cord for pulpwood (P).

* Denotes worst case scenario

** Denotes best case scenario

Table 1.--Characteristics of control methods and incremental value expected at rotation because of control on the National Forests in Mississippi, continued.

Method of Control	Cost/AC	Expected % of BA in Hardwood At Crown Closure	Expected % Hardwood Controlled	Stumpage Price At Harvest (S/P)[1]	Incremental Stumpage Value
Foliar spray	$105	70	60	$353/$12	$2,164
(CTMSS)		**70	70		2,946
Prescribed burn		*80	60		1,830
		80	70		2,671
Inject Cehmicals	$120	80	70		$2,671
Basal spray,		**80	80		3,605
Prescribe burn		*90	70		1,972
		90	80		3,394
Stem breakage	$175	**90	85		$3,900
Soil Active Herbicides, Prescribed burn		*90	95		4,807
Shear & Rake	$95	50	70		$3,021
Prescribed burn		**50	80		3,545
		*70	70		2,751
		70	80		3,516

1 Price per MBF for sawtimber (S) and per cord for pulpwood (P).

* Denotes worst case scenario

** Denotes best case scenario

Table 2.--Characteristics of control methods and incremental value expected at rotation because of control on the Chattahoochee National Forest (Georgia)

Method of Control	Cost/AC	Expected % of BA in Hardwood At Crown Closure	Expected % Hardwood Controlled	Stumpage Price At Harvest (S/P)[1]	Incremental Stumpage Value
Prescribed burn	$23	40	25	$195/$4	$ 341
		**40	50		704
		*80	25		124
		80	50		394
Cut/Surface Treatments (Injection)	$70	55	30		$ 327
		**55	80		1,346
		*85	30		115
		85	80		1,227
Chemical Treatments	$62	55	40		$ 484
		**55	70		1,116
		*85	40		208
		85	70		883
Drum Chop	$80	40	20		$ 289
		**40	70		1,058
		*80	20		69
		80	70		917

1 Price per MBF for sawtimber (S) and per cord for pulpwood (P).

* Denotes worst case scenario

** Denotes best case scenario

Table 3.--Characteristics of control methods and incremental value expected at rotation because of control on the Ouachita National Forest (Arkansas)

Method of Control	Cost/AC	Expected % of BA in Hardwood At Crown Closure	**Expected % Hardwood Controlled**	Stumpage Price At Harvest (S/P)[1]	Incremental Stumpage Value
Drum chop with	$85	40	60	$251/$19	$1,909
Prescribed burn		**40	90		2,794
		*60	60		1,826
		60	90		3,242
Burning and	$65	40	60		$1,927
Injection		**40	90		2,823
		*60	60		1,845
		60	90		3,274
Chopping,	$118	50	60		$2,008
Ripping		**50	80		2,839
Burning		*70	60		1,680
		70	80		2,856
Soil Herbicide	$128	50	60		$2,080
treatment		**50	90		3,311
(Velpar L)		*70	60		1,748
& ripping		70	90		3,525
Slash & stump	$121	50	50		$1,606
spray herbicide		**50	60		2,039
& ripping		*70	50		1,193
		70	60		1,714

1. Price per MBF for sawtimber (S) and per cord for pulpwood (P)

* Denotes worst case scenario.

** Denotes best case scenario.

Table 4.--Expected harvest volume with no hardwood competition and change in volume due to soil productivity and hardwood control on the National Forests in Mississippi (average site index 55).

Method of Control	Expected % of BA in Hwd. at Crown Closure	Expected % Hwd. Controlled	Exptd. Vol/Ac W/No Hwd. Control or Soil Prod. Impacts	Exptd. Change in Vol/Ac due to Soil Prod. Impacts	Exptd. Change in Volume W/Hwd. Control	Total Wood Vol. with Control
Granular	60	70	.6 MBF/3.6 CDS	-.1 MBF/-.2 CDS	8.7 MBF/11.1 CDS	9.2 MBF/14.5 CDS
Herbicide	**60	80	.6 MBF/3.6 CDS	-.1 MBF/-.2 CDS	10.7 MBF/11.6 CDS	11.2 MBF/15.0 CDS
Followed by	*70	70	.2 MBF/1.9 CDS	-.1 MBF/-.2 CDS	8.2 MBF/12.4 CDS	8.2 MBF/14.1 CDS
Prescribed Burn	70	80	.2 MBF/1.9 CDS	-.2 MBF/-.2 CDS	10.4 MBF/13.2 CDS	10.4 MBF/14.9 CDS
Foliar Spray,	70	70	.2 MBF/1.9 CDS	-.1 MBF/-.2 CDS	8.1 MBF/12.4 CDS	8.2 MBF/14.1 CDS
Inject Stems,	**70	80	.2 MBF/1.9 CDS	-.2 MBF/-.2 CDS	10.4 MBF/13.2 CDS	10.4 MBF/14.9 CDS
Prescribed Burn	*80	70	.1 MBF/ .9 CDS	-.1 MBF/-.2 CDS	7.2 MBF/12.9 CDS	7.2 MBF/13.6 CDS
	80	80	.1 MBF/ .9 CDS	-.1 MBF/-.2 CDS	9.9 MBF/14.0 CDS	9.9 MBF/14.7 CDS
Stump Spray	60	60	.6 MBF/3.6 CDS	.2 MBF/ .3 CDS	6.7 MBF/10.2 CDS	7.5 MBF/14.1 CDS
With	**60	70	.6 MBF/3.6 CDS	.1 MBF/ .3 CDS	8.7 MBF/11.6 CDS	9.5 MBF/15.8 CDS
Herbicide	*70	60	.2 MBF/1.9 CDS	.1 MBF/ .3 CDS	5.8 MBF/11.3 CDS	6.1 MBF/13.5 CDS
	70	70	.2 MBF/1.9 CDS	.2 MBF/ .3 CDS	8.1 MBF/12.4 CDS	8.5 MBF/14.6 CDS
	70	70	.2 MBF/1.9 CDS	.2 MBF/ .3 CDS	8.1 MBF/12.4 CDS	8.5 MBF/14.6 CDS
Prescribed Brun	80	70	.1 MBF/ .9 CDS	-.1 MBF/-.2 CDS	7.2 MBF/12.9 CDS	7.2 MBF/12.9 CDS
Followed By	**80	80	.1 MBF/ .9 CDS	-.1 MBF/-.2 CDS	9.9 MBF/14.0 CDS	9.9 MBF/14.7 CDS
Injection	*90	70	.0 MBF/ .4 CDS	-.1 MBF/-.2 CDS	6.4 MBF/13.0 CDS	6.3 MBF/13.2 CDS
	90	80	.0 MBF/ .4 CDS	-.1 MBF/-.2 CDS	9.3 MBF/14.3 CDS	9.2 MBF/14.5 CDS
Chemical	70	60	.2 MBF/1.9 CDS	.1 MBF/ .3 CDS	5.8 MBF/11.3 CDS	6.1 MBF/13.5 CDS
Injection	**70	70	.2 MBF/1.9 CDS	.2 MBF/ .3 CDS	8.1 MBF/12.4 CDS	8.5 MBF/14.6 CDS
	*80	60	.1 MBF/ .9 CDS	.1 MBF/ .3 CDS	4.9 MBF/11.4 CDS	5.1 MBF/12.6 CDS
	80	70	.1 MBF/ .9 CDS	.2 MBF/ .3 CDS	7.2 MBF/12.9 CDS	7.5 MBF/14.1 CDS

Continued

Table 4.--Expected harvest volume with no hardwood competition and change in volume due to soil productivity and hardwood control on the National Forests in Mississippi (average site index 55), continued.

Method of Control	Expected % of BA in Hwd. at Crown Closure	Expected % Hwd. Controlled	Exptd. Vol/Ac W/No Hwd. Control or Soil Prod. Impacts	Exptd. Change in Vol/Ac due to Soil Prod. Impacts	Exptd. Change in Volume W/Hwd. Control	Total Wood Vol. with Control
Soil Active	**90	80	.0 MBF/ .4 CDS	.2 MBF/ .4 CDS	9.3 MBF/14.3 CDS	9.5 MBF/14.7 CDS
Herbicide	*90	90	.0 MBF/ .4 CDS	.3 MBF/ .4 CDS	12.2 MBF/14.3 CDS	12.5 MBF/14.7 CDS
(Velpar L) Applied by Spot Gun Followed by Prescribed Burn						
Foliar Spray	70	60	.2 MBF/1.9 CDS	-.1 MBF/-.2 CDS	5.8 MBF/11.2 CDS	5.9 MBF/13.0 CDS
(CTMSS)	**70	70	.2 MBS/1.9 CDS	-.1 MBF/-.2 CDS	8.1 MBF/12.4 CDS	8.2 MBF/14.1 CDS
Prescribed	*80	60	.1 MBF/ .9 CDS	-.1 MBF/-.2 CDS	4.9 MBF/11.4 CDS	4.9 MBF/12.1 CDS
Burn	80	70	.1 MBF/ .9 CDS	-.1 MBF/-.2 CDS	7.2 MBF/12.9 CDS	7.2 MBF/13.6 CDS
Inject	80	70	.1 MBF/ .9 CDS	-.1 MBF/-.2 CDS	7.2 MBF/12.9 CDS	7.2 MBF/13.6 CDS
Chemicals,	**80	80	.1 MBF/ .9 CDS	-.1 MBF/-.2 CDS	9.9 MBF/14.0 CDS	9.9 MBF/14.7 CDS
Basal Spray,	*90	70	.0 MBF/ .4 CDS	-.1 MBF/-.2 CDS	6.4 MBF/13.0 CDS	6.3 MBF/13.2 CDS
Prescribed Burn	90	80	.0 MBF/ .4 CDS	-.1 MBF/-.2 CDS	9.3 MBF/14.3 CDS	9.2 MBF/14.5 CDS
Stem Breakage,	**90	85	.0 MBF/ .4 CDS	-.2 MBF/-.3 CDS	10.8 MBF/14.7 CDS	10.6 MBF/14.4 CDS
Soil Active	*90	95	.0 MBF/ .4 CDS	-.3 MBF/-.3 CDS	13.4 MBF/15.0 CDS	13.4 MBF/14.7 CDS
Herbicide, Prescribed Burn						
Shear, Rake	50	70	1.3 MBF/6.0 CDS	.7 MBF/ .7 CDS	9.0 MBF/ 9.0 CDS	9.6 MBF/14.3 CDS
Prescribed	**50	80	1.3 MBF/6.0 CDS	.8 MBF/ .8 CDS	10.6 MBF/11.1 CDS	11.1 MBF/14.6 CDS
Burn	*70	70	.2 MBF/1.9 CDS	.6 MBF/1.0 CDS	8.1 MBF/12.4 CDS	7.7 MBF/13.3 CDS
	70	80	.2 MBF/1.9 CDS	.8 MBF/1.1 CDS	10.4 MBF/13.2 CDS	9.8 MBF/14.0 CDS

** Denotes worst case scenario

* Denotes best case scenario

Table 5.--Expected harvest volume with no hardwood competition and change in volume due to soil productivity and hardwood control on the Chattahoochee National Forest in Georgia (site index 48).

Method of Control	Expected % of BA in Hwd. at Crown Closure	Expected % Hwd. Controlled	Exptd. Vol/Ac W/No Hwd. Control or Soil Prod. Impacts	Exptd. Change in Vol/Ac due to Soil Prod. Impacts	Exptd. Change in Volume W/Hwd. Control	Total Wood Vol. with Control
Prescribed	40	25	1.7 MBF/7.2 CDS	-.1 MBF/-.1 CDS	1.7 MBF/ 3.7 CDS	3.3 MBF/10.8 CDS
Fire	**40	50	1.7 MBF/7.2 CDS	-.1 MBF/-.2 CDS	3.6 MBF/ 5.8 CDS	5.2 MBF/12.8 CDS
	*80	25	.1 MBF/ .9 CDS	/-.1 CDS	.5 MBF/ 2.7 CDS	.6 MBF/ 3.5 CDS
	80	50	.1 MBF/1.9 CDS	-.1 MBF/-.3 CDS	1.9 MBF/ 7.5 CDS	1.9 MBF/ 8.1 CDS
Cut Surface	55	30	.6 MBF/4.0 CDS	/ .1 CDS	1.5 MBF/ 4.9 CDS	2.1 MBF/ 9.0 CDS
Treatments	**55	80	.6 MBF/4.0 CDS	.1 MBF/ .2 CDS	6.6 MBF/10.0 CDS	7.3 MBF/14.2 CDS
(Injection)	*85	30	/1.6 CDS	/ .1 CDS	.5 MBF/ 3.1 CDS	.5 MBF/ 3.8 CDS
	85	80	/1.6 CDS	.1 MBF/ .3 CDS	5.9 MBF/12.8 CDS	6.0 MBF/13.7 CDS
Chemical	55	40	.6 MBF/6.3 CDS	/ .1 CDS	2.3 MBF/ 6.3 CDS	2.9 MBF/12.7 CDS
Treatments	**55	70	.6 MBF/6.3 CDS	.1 MBF/ .2 CDS	5.4 MBF/ 9.5 CDS	6.1 MBF/16.0 CDS
	*85	40	/ .1 CDS	/ .1 CDS	.9 MBF/ 5.1 CDS	.9 MBF/ 5.3 CDS
	85	70	/ .1 CDS	/ .2 CDS	4.2 MBF/11.3 CDS	4.2 MBF/11.6 CDS
Drum Chop	40	20	1.7 MBF/7.2 CDS		1.4 MBF/ 3.2 CDS	3.1 MBF/10.5 CDS
	**40	70	1.7 MBF/7.2 CDS		5.3 MBF/ 6.7 CDS	7.0 MBF/13.9 CDS
	*80	20	.1 MBF/1.9 CDS	.3 MBF/ 2.0 CDS	.4 MBF/ 2.9 CDS	
	80	70	.1 MBF .9 CDS	4.5 MBF/11.3 CDS	4.6 MBF/12.2 CDS	

** Denotes worst case scenario

* Denotes best case scenario

Table 6.--Expected harvest volume with no hardwood competition and change in volume due to soil productivity and hardwood control on the Ouachita National Forest in Arkansas (average site index 55).

Method of Control	Expected % of BA in Hwd. at Crown Closure	Expected % Hwd. Controlled	Exptd. Vol/Ac W/No Hwd. Control or Soil Prod. Impacts	Exptd. Change in Vol/Ac due to Soil Prod. Impacts	Exptd. Change in Volume W/Hwd. Control	Total Wood Vol. with Control
Drum Chop	40	60	2.6 MBF/8.7 CDS.	-.2 MBF/-.2 CDS.	7.4 MBF/ 6.2 CDS.	9.8 MBF/14.7 CDS
With	**40	90	2.6 MBF/8.7 CDS.	-.3 MBF/-.2 CDS.	10.9 MBF/ 7.1 CDS.	13.2 MBF/15.6 CDS
Prescribed	*60	90	.6 MBF/3.6 CDS.	-.2 MBF/-.3 CDS	6.7 MBF/10.2 CDS.	7.1 MBF/13.5 CDS
Burn	60	90	.6 MBF/3.6 CDS.	-.4 MBF/-.4 CDS	12.4 MBF/11.8 CDS.	12.6 MBF/15.0 CDS
Burning	40	60	2.6 MBF/8.7 CDS.	-.1 MBF/-.1 CDS.	7.4 MBF/ 6.2 CDS.	9.9 MBF/14.8 CDS
And	**40	90	2.6 MBF/8.7 CDS.	-.2 MBF/-.1 CDS.	10.9 MBF/ 7.1 CDS.	13.3 MBF/15.7 CDS
Injection	*60	60	.6 MBF/3.6 CDS.	-.1 MBF/-.2 CDS.	6.7 MBF/10.2 CDS.	7.2 MBF/13.6 CDS
	60	90	.6 MBF/3.6 CDS.	-.2 MBF/-.2 CDS.	12.4 MBF/11.8 CDS.	12.8 MBF/15.2 CDS
Chopping	50	60	1.3 MBF/7.5 CDS.		7.3 MBF/ 8.4 CDS.	8.6 MBF/15.9 CDS
And	**50	80	1.3 MBF/7.5 CDS.		10.6 MBF/ 9.5 CDS.	11.9 MBF/17.0 CDS
Spraying	*70	60	.2 MBF/1.9 CDS.		a5.8 MBF/11.3 CDS.	6.0 MBF/13.2 CDS
	70	80	.2 MBF/1.9 CDS.		10.4 MBF/13.2 CDS.	10.6 MBF/15.1 CDS
Soil Herbicide	50	60	1.3 MBF/7.5 CDS.	.3 MBF/ .3 CDS.	7.3 MBF/ 8.4 CDS.	8.9 MBF/16.2 CDS
Treatment	**50	90	1.3 MBF/7.5 CDS.	.5 MBF/ .4 CDS.	12.0 MBF/ 9.4 CDS.	13.8 MBF/17.3 CDS
(Velpar L)	*70	60	.2 MBF/1.9 CDS.	.2 MBF/ .5 CDS.	5.8 MBF/11.3 CDS.	6.2 MBF/13.7 CDS
And Ripping	70	90	.2 MBF/1.9 CDS.	.5 MBF/ .5 CDS.	12.5 MBF/13.5 CDS.	13.2 MBF/15.9 CDS
Slash and	50	50	1.3 MBF/7.5 CDS.	.1 MBF/ .2 CDS.	5.7 MBF/ 7.6 CDS.	7.1 MBF/15.3 CDS
Stump spray	**50	60	1.3 MBF/7.5 CDS.	.1 MBF/ .2 CDS.	7.3 MBF/ 8.4 CDS.	8.7 MBF/16.1 CDS
Herbicide and	*70	50	.2 MBF/1.9 CDS.	.1 MBF/ .2 CDS.	3.9 MBF/ 9.6 CDS.	4.2 MBF/11.7 CDS
Ripping	70	60	.2 MBF/1.9 CDS.	.1 MBF/ .2 CDS.	5.8 MBF/11.3 CDS.	6.1 MBF/13.4 CDS

** Denotes worst case scenario

* Denotes best case scenario

Table 7.--Estimated economic performance criteria by method of control on the National Forests in Mississippi.

Method of Control	Cost/AC	Incremental Stumpage Value	Present Value	Net Present Value	Incremental Real IRR	Incremental Nominal IRR 1/
Granular Herbicide followed by Prescribed burn	$90	$3,159	$541	$451	8.2%	13.6%
		3,852	659	569	8.7 **	14.1
		2,946	504	414	8.1 *	13.5
		3,764	644	554	8.7	14.1
Foliar spray, Inject Stems, Prescribed burn	$140	$2,946	$504	$364	7.0%	12.4%
		3,764	644	504	7.6 **	13.0
		2,671	457	317	6.8 *	12.1
		3,605	617	477	7.5	12.9
Stump spray W/Herbicide	$40	$2,560	$438	$398	9.7%	15.2%
		3,294	564	524	10.3 **	15.8
		2,251	385	345	9.4 *	14.9
		3,066	525	485	10.1	15.6
Prescribed burn followed by Injection	$80	$2,671	457	377	8.1%	13.5%
		3,605	617	537	8.8 **	14.2
		1,972	338	258	7.4 *	12.8
		3,394	581	501	8.7	14.1
Chemical Injection	$70	$2,251	385	315	8.0%	13.4%
		3,066	525	455	8.8 **	14.2
		1,904	326	256	7.6 *	13.0
		2,779	581	511	8.5	13.9
Soil Active Herbicide (Velpar) Applied by spot gun, followed by Prescribed burn	$130	$3,532	605	475	7.6%**	13.0%
		4,581	784	654	8.2 *	13.6

Continued

1 Assumes 5% Annual Inflation
* Denotes worst case scenario
** Denotes best case scenario

Table 7.--Estimated economic performance criteria by method of control on the National Forests in Mississippi, continued.

Method of Control	Cost/AC	Incremental Stumpage Value	Present Value	Net Present Value	Incremental Real IRR	Incremental Nominal IRR 1/
Foliar spray	$ 105	$ 2,164	$ 370	$ 265	7.0%	12.4$
(CTMSS) followed		2,946	504	399	7.7 **	13.1
by Prescribed burn		1,830	313	208	6.6 *	11.9
		2,671	457	352	7.5	12.9
Inject Chemicals	$ 120	$ 2,671	$ 475	$ 337	7.1%	12.5%
Basal Spray		3,605	617	497	7.9 **	13.3
Prescribed burn		1,972	338	218	6.4 *	11.7
		3,394	581	461	7.7	13.1
Stem breakage	$ 175	$ 3,900	$ 668	$ 493	7.1%**	12.5%
Soil Active Herbicides		4,807	823	648	7.6 *	13.0
Prescribed burn						
Shear & Rake	$ 95	$ 3,021	$ 517	$ 422	8.0	13.4$
Prescribed burn		3,545	607	512	8.4 **	13.8
		2,751	471	376	7.8 *	13.2
		3,516	602	507	7.8	13.2

1 Assumes 5% Annual Inflation

* Denotes worst case scenario

** Denotes best case scenario

Table 8.--Estimated economic performance criteria by method of control on the Chattahoochee National Forest (Georgia).

Method of Control	Cost/AC	Incremental Stumpage Value	Present Value	Net Present Value	Incremental Real IRR	Incremental Nominal IRR 1/
Prescribed burn	$ 23	$ 341	$ 58	$ 35	6.2%	11.5%
		704	121	98	7.9 **	13.3
		124	21	- 2	3.8 *	9.0
		394	67	44	6.5	11.8
Cut/Surface Treatments (Injection)	$ 70	$ 327	$ 56	$-14	3.5%	8.7%
		1,346	230	160	6.8 **	12.1
		115	20	-50	1.1 *	6.2
		1,227	210	140	6.6	11.9
Chemical Treatments	$ 62	$ 484	$ 83	$ 21	4.7%	9.9%
		1,116	191	129	6.6 **	11.9
		208	36	-26	2.7 *	7.8
		883	151	89	6.1	11.4
Drum Chop	$ 80	$ 289	$ 49	$-31	2.9%	8.1%
		1,058	181	101	5.9 **	11.2
		69	12	-68	0.3 *	1.9
		917	157	77	5.6	10.9

1./ Assumes 5% Annual Inflation

* Denotes worst case scenario

** Denotes best case scenario

Table 9.--Estimated economic performance criteria by method of control, Ouachita National Forest (Arkansas).

Method of Control	Cost/AC	Incremental Stumpage Value	Present Value	Net Present Value	Incremental Real IRR	Incremental Nominal IRR 1/
Drum Chop with	$ 85	$1,909	$327	$242	7.2%	12.6%
Prescribed burn		2,794	478	393	8.1 **	13.5
		1,826	313	228	7.1 *	12.5
		3,242	555	470	8.4	13.8
Burning and	$ 65	$1,927	$330	$265	7.8%	13.2%
Injection		2,823	483	418	8.7 **	14.1
		1,845	316	251	7.7 *	13.1
		3,274	561	496	9.1	14.6
Chopping,	$118	$2,008	$344	$226	6.5%	11.8%
Ripping,		2,839	486	368	7.3 **	12.7
Burning		1,680	288	170	6.1 *	11.4
		2,856	489	371	7.3	12.7
Soil Herbicide	$128	$2,080	$356	$228	6.4%	11.7%
Treatment		3,311	567	439	7.5 **	12.9
(Velpar L)		1,748	299	171	6.0 *	11.3
and Ripping		3,525	603	475	7.7	13.1
Slash & stump	$121	$1,606	$275	$154	5.9%	11.2%
Spray herbicide		2,039	349	228	6.5 **	11.8
and Ripping		1,193	204	83	5.2 *	10.5
		1,714	293	172	6.1	11.4

1. / Assumes 5% Annual Inflation

* Denotes worst case scenario

** Denotes best case scenario

The Forest Service, U.S. Department of Agriculture, is responsible for Federal leadership in forestry. It carries out this role through four main activities:

- Protection and management of resources on 191 million acres of National Forest System lands.
- Cooperation with State and local governments, forest industries, and private landowners to help protect and manage non-Federal forest and associated range and watershed lands.
- Participation with other agencies in human resource and community assistance programs to improve living conditions in rural areas.
- Research on all aspects of forestry, rangeland management, and forest resources utilization.

The Southern Region

- Represents the National Forest System and the State and Private Forestry branches of the Forest Service in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, Texas, Virginia, and U.S. Virgin Islands.